BAD RIVER SECTION 319 NATIONAL MONITORING PROJECT
FINAL REPORT

South Dakota Department of Environment and Natural Resources

For
U.S. Environmental Protection Agency

October 2013

This project was conducted in cooperation with the state of South Dakota and the United States Environmental Protection Agency, Region 8.

Grant # 99818595, 99818599

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EXECUTIVE SUMMARY

PROJECT TITLE: BAD RIVER SECTION 319 NATIONAL MONITORING PROJECT

SECTION 319 GRANT NUMBER: C99818595, C99818599

PROJECT START DATE: 1996

PROJECT COMPLETION DATE: 2006

FUNDING:	TOTAL BUDGET	383,706
	TOTAL EPA GRANT(S)	303,406
	OTHER FUNDING	80,300
	TOTAL EXPENDITURES	383,706

Project Element	**Funding Source ($)**				
Federal	**Federal**	**State**		**Local**	**Sum**
Land Treatment	154,428	2,000	NA		156,428
WQ Monitoring	148,978	18,300	NA		167,278
Add'l Robel Pole				60,000	60,000
TOTALS	303,406	20,300		60,000	383,706

Source: Bad River National Monitoring Project Workplan, 1996

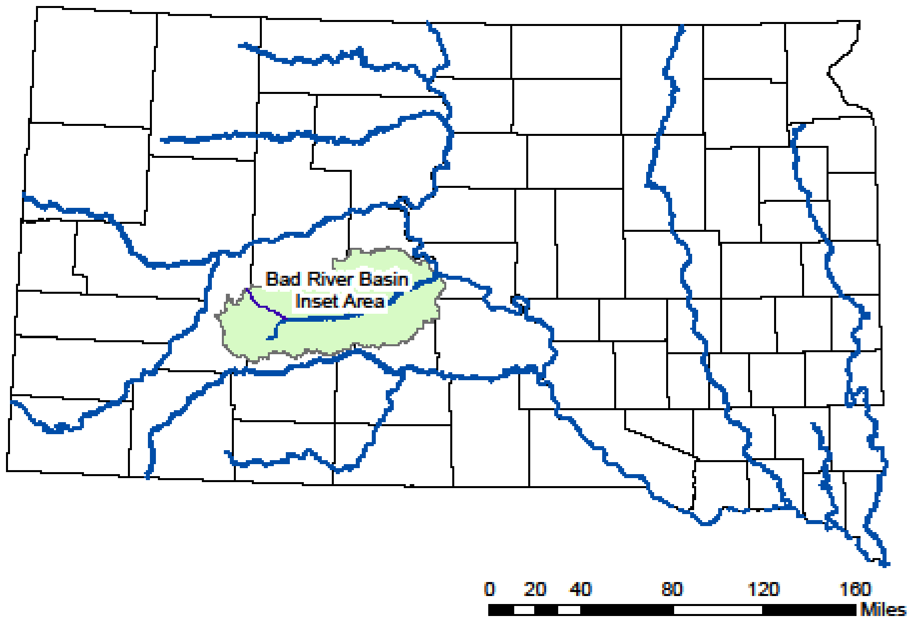
The Bad River National Monitoring Project's goal was to assess the success of best management practice (BMP) implementation projects in Phase III of the Bad River Water Quality Project by documenting water quality and rangeland health improvements. Initially the goals were to conduct a paired watershed study in both an upper and lower area of the basin where water quality and range data would be collected. Transects and monitoring equipment were established and data was collected.

Due to BMP placement changes and land ownership issues outside the control of this project, the paired watershed approach in the lower Bad River watershed was not able to be analyzed. No direct connection was found between BMP treatment and water quality or range improvement within the scope of the upper basin watershed. Using a regional remote sensing approach and by examining USGS Bad River stream gage data at the outlet, there is a correlation between BMPs and both water quality and stream health.

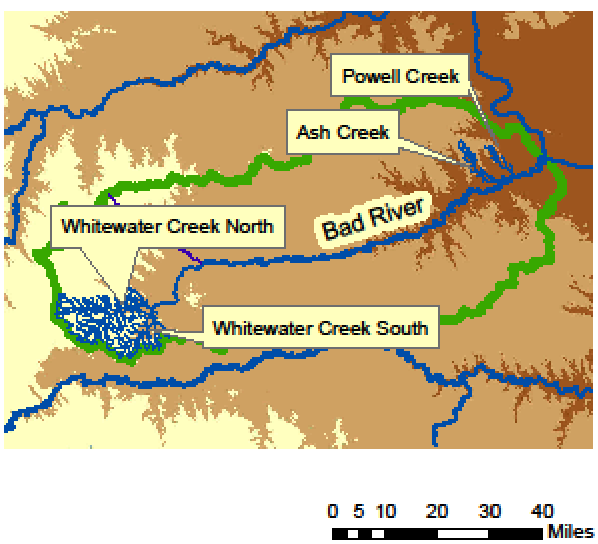
INTRODUCTION:

The Bad River watershed, located in west central South Dakota (Figure 1), consists mainly of rangeland with about a third of the land used as cropland. Livestock grazing and dryland wheat farming are the dominant land uses in the watershed. The Bad River empties into the Missouri River at its mouth, near Fort Pierre, South Dakota. Soil erosion, primarily from poor grazing management and poorly maintained riparian areas, causes excessive sedimentation to the main channel of the Missouri River. This sedimentation has impaired recreation due to loss of depth in the Missouri Channel (Thelen, 2004). Loss of channel depth below the dam for the Oahe Reservoir on the Missouri River, located 10 miles upstream from the mouth of the Bad River, has impaired the hydropower generation of Oahe Dam during winter months. Loss of channel depth is blamed for flooding in the cities of Pierre and Fort Pierre. Recreational fishing is also negatively affected by sediment from the Bad River (SDGFP, 1985).

Figure 1: Bad River Basin in west-central South Dakota



Bad River Basin Inset Area



The Bad River Section 319 National Monitoring Project was designed to test the effectiveness of BMPs implemented for sediment control on two paired subwatersheds in the Bad River basin of South Dakota. The Bad River NMP began in 1996 and monitoring continued until 2006. This monitoring program was built on related studies, shown below in Table 1.

Table 1- Existing Studies in the Bad River Watershed

Study	Completion Date	Activities/Conclusion
Phase I and IB	1990	Badlands soils are not a major sediment source. Cropland is not a major sediment source. The lower one-third of the Bad River drainage area is the major source of sediment.
Lower Bad River- River Basin Study	1994	72 percent of sediment is from the lower third of the drainage area. Gully and channel erosion are the primary sources.
Phase II	1995	Identified cost-effective land treatment practices.
Phase III	1995	Initiated best management practices (BMP) implementation in the lower basin.
Upper Bad River- River Basin Study	1998	Identified priority areas for implementation projects.
Demonstration Project	2000	Developed project and local ownership in the upper basin.

Source: Upper Bad River Basin Study, 1998.

The Bad River Phase I project determined that rangeland was the major source of sediment within the basin. Bad River Phase II project explored how natural resource managers and producers could implement the most efficient BMPs appropriate for the region. The Lower Bad River Basin Study allocated the sources of erosion to different sources within the region and set a 30% sediment reduction goal to comply with the TDML. Phase III was a major implementation project which installed BMPs whose effects had been proven effective in Phase II, on 120,000 acres of the lower section of the Bad River. The Bad River Phase III Implementation Project was coordinated by the Stanley County Conservation District. The District identified landowners willing to participate in the project through public meetings and personal contacts and facilitated BMP placement on producer land (Thelen, 2004).

The National Monitoring Project was to assess the success of the Phase III Implementation project in reducing erosion on 25,000 acres of the lower watershed and on 14,000 acres in the upper watershed

PROJECT LOCATION AND DESCRIPTION

The drainage area of the Bad River is located in west-central South Dakota (Figure 1) and covers 3,209 square miles of mostly rangeland. The rolling topography of fine textured, deep, shale-derived soils allows for significant soil erosion when rangeland and cropland is not properly managed. The project area supports an abundance of wildlife including mule deer, pronghorn, porcupines, bobcats, prairie grouse, prairie dogs, bison, and numerous other species. This area of South Dakota receives, on average 15-16 inches of rainfall per year, though rainfall is highly variable. Most of the precipitation is from spring and summer thunderstorms, although snowmelt can produce significant runoff. The land use in the watershed is primarily agricultural and consists of 75% rangeland and 25% dryland wheat farming. A large portion of the upper end of the Bad River watershed is owned by the U.S. Forest Service. Rotational grazing practices have been implemented on the federal rangeland and also on many private ranches.

The official beneficial uses of the Bad River include the following:

- Warmwater marginal fish life propagation waters
- Limited contact recreation waters
- Fish and wildlife propagation, recreation and stock watering waters
- Irrigation waters

The main impairment to the Bad River is excess sediment from eroded soils in rangeland and riparian areas. The load of sediment from the Bad River creates channel capacity and water clarity impacts on sport fishing in the Missouri near the mouth of the Bad River. The Bad River National Monitoring Project was designed to test the effectiveness of BMPs implemented to reduce sediment to the Bad River on two paired subwatersheds in the Bad River basin of South Dakota

One pair of watersheds was located near the mouth of the Bad River. Ash Creek (originally scheduled to be the control) contains 13,702 acres and Powell Creek (treatment), is comprised of 11,221 acres (Figure 2). BMPs were installed in both watersheds starting in 1995 as part of the Bad River Water Quality Implementation Project in the eastern/lower part of the watershed. In 1997, fencing and off site water practices were put in place. More BMPs were implemented in the watershed including no-till row cropping, CRP, and riparian buffers (Vande Kamp, 2012). BMPs including sediment control structures were implemented between 1997 and 2002 (Vande Kamp, 2012) in both Ash and Powell Creek watersheds. Ash Creek watershed experienced

BMP implementation covering 77% of the area. Managed grazing was implemented throughout the watersheds.

In 2001, Turner Enterprises purchased the Bad River Ranch, approximately 141,000 acres in the Bad River watershed. Land purchased included the Ash and Powell watersheds which were the eastern paired watersheds for the NMP study. Both watersheds had already received substantial treatment, but the land transfer halted whatever land treatment difference still existed between the two watersheds. In 2002, his operation changed the grazing regime from cattle to bison (Rigge, 2013), a significant change in land use.

The ability to analyze Ash and Powell Creeks for vegetation and total suspended solids (TSS) data is limited to examining pre- and post- treatment data separately in each watershed. This before-after design had its own problems however. As range condition was only measured till 2002, one year of post-treatment is insufficient to draw conclusions about the effects of BMP watersheds in this case. The 'before' period is problematic as well with BMPs implemented and land management practices changing between 1995 and 2002, there is no clear cut treatment. 1996 and 1997 were scheduled to be pre- treatment years when calibration data could be collected. Data collection was limited in 1996 at the beginning of the NMP project.

The western pair of watersheds, Whitewater Creek North (6,780 acres, treatment) and Whitewater Creek South (6,605 acres, control) are primarily owned, and managed by the federal government (Figure 3). In 1991, some grazing practices were changed in Whitewater North with fencing dividing pasture and some cattle moved to utilize off site water practices (OSWP)(Rigge, 2013). This was a major shift in land use and it was probable that Whitewater Creek North was still feeling those effects. Due to political conflicts over the use of public lands, federal land managers were not able to fully implement grazing management in those watersheds. BMPs were installed in Whitewater Creek North one year behind schedule, in 2000. These watersheds were monitored and analyzed using a 'before-after-control-impact' design.

Alternate methods of assessing BMP success in these watersheds include remote sensing techniques. A 2010 re-classification of channel morphology in Ash Creek from pre-BMP 1994 revealed changes in Rosgen Class which indicates a reduced sediment load, fewer numbers of eroding banks, and channel sinuosity increased (Vande Kamp 2012). Success in Ash Creek which attributed to increased cover of prairie cordgrass which was verified by remote sensing techniques (Rigge, 2013).

Figure 2: Ash Creek and Powell Creek watersheds

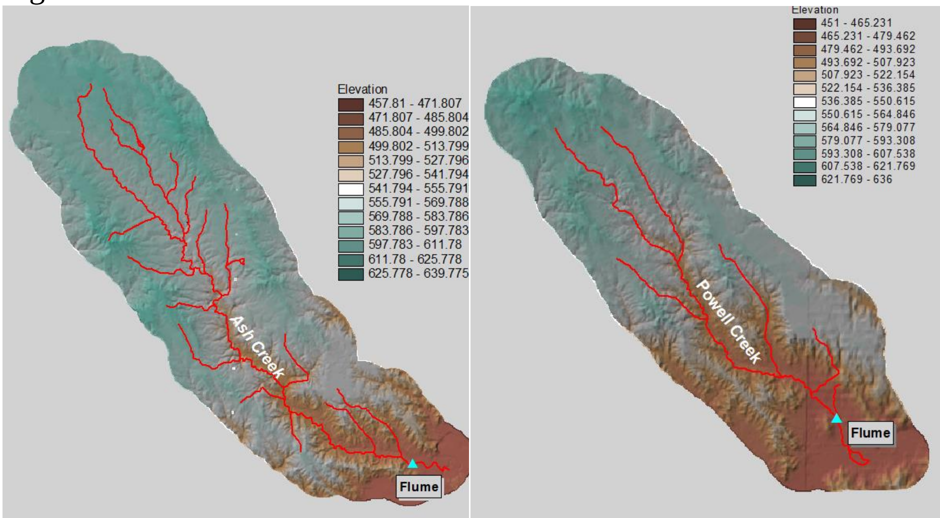
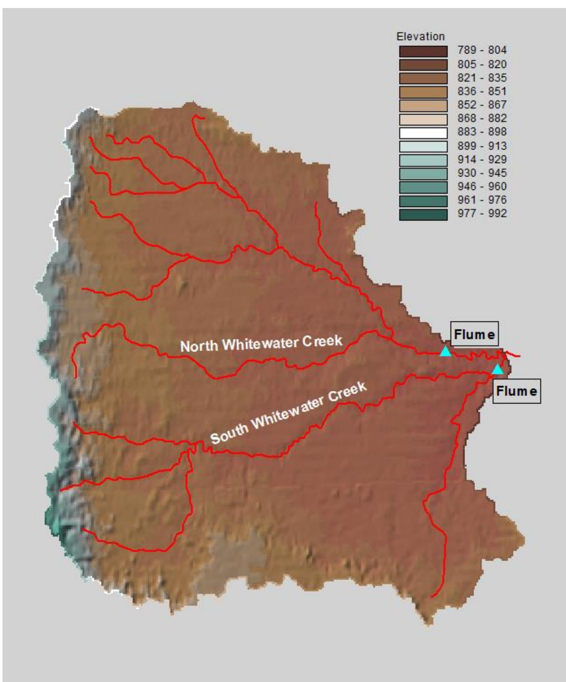


Figure 3: Whitewater Creek watershed



PROJECT GOALS, OBJECTIVES, METHODS, and ACTIVITIES

The main objective for this project was to document water quality improvements through a decrease in total suspended solids in the treatment subwatersheds due to the implementation of BMPs. Initially this was hoped to be accomplished by:

1. Establishment of monitoring stations for water quality and hydrologic data collection.
2. Monitoring rangeland condition in each watershed.
3. Monitoring riparian condition to determine the effects of BMPs on the condition of riparian habitat.

After design changes in the paired watershed experiment, objectives were expanded to include:

1. Quantifying sediment rate change in the Bad River watershed using a pre- and post-BMP comparison using remote sensing.
2. Quantifying positive vegetation changes in the Bad River watershed using a pre- and post-BMP comparison using remote sensing.

Water Quality Monitoring

The streams in this area are ephemeral, so monitoring is storm-event driven. Stream gaging was done using Parshall Flumes with Isco bubbler flow meters calibrated to the flumes. Samples were collected using Isco auto samplers with composite bases. Sampling was done on a flow paced basis during storm events. Storm event occurrence, rainfall amounts, and rainfall intensity were to be compared with the hydrologic discharge and sediment loads. Composite samples were to be collected and analyzed for the duration of flow of each storm event. The water quality parameters to be measured were total suspended solids, stream discharge, and rainfall. Problems arose when collecting data as flow meters clogged frequently. Rainfall and storm intensity varied from site to site, activation switches corroded, and rodents ate through the insulation and the wire core of the activation switches. Due to the drought and natural low flow conditions only 28% of events sampled at Whitewater Creek actually had nonzero flow (Rigge, 2013). 32% of events at Powell Creek had nonzero flow.

Land Treatment Monitoring

Rangeland was to be monitored by measuring range condition and vegetative cover during the project period. Range condition was to be characterized at the start of the project, five years into the project and at the end of the project. Range condition was never quantified by NRCS personnel. Range condition is a subjective method meant to pick monitoring sites or gather preliminary data about sites, not to "identify the cause(s) of resource problems or to "monitor land or determine trend (NRCS, 2005)." In short, range condition assessment was not a valid tool to measure long-term change.

The Robel Pole method was used to determine vegetative cover at permanent transects located within each subwatershed (Ash Creek — 21 transects, Powell Creek — 13 transects, Whitewater North — 10 transects, and Whitewater South — 9 transects). The Robel Pole measurements were to be taken 3 times per transect per year, spring, summer and fall. Daubenmire frames were utilized to estimate cover classes of 'rock' 'bare ground' 'shrub' 'forbs' and 'grass'. Stations were classified either as warm or cool season dominated grasses. Riparian condition was to be monitored using photopoints and bank pins to measure erosion.

Remote Sensing and other methods

There was little useful pre-BMP rangeland and total suspended solids data. Powell and Ash watersheds could only be analyzed by using a 'before-after' approach in which the 'before' and 'after' periods were questionable in definition. SDSU scientists were able to use remote sensing data in cooperation with EROS using a CEAP grant to link warm season grass cover which facilitates healthy streams to BMP implementation. Their methods and conclusions are in the attached papers. They also used historical flow data in the Bad River to show a decrease in sediment loads from 'pre'- to 'post'- BMP time periods in a yet to be published paper. The USGS maintains continuous flow data including sediment measurements at stations across South Dakota. Data from the gauge at the mouth of the Bad River dating back to 1972 was used to assess changes in flow and sediment for the pre-BMP period 1972-1991, BMP installation period 1991-2002 and post-BMP data, 2003-2012.

BEST MANAGEMENT PRACTICES IMPLEMENTED

BMPs were implemented where producers in cooperation with NRCS thought they would be most useful. As this was a voluntary program, BMPs were placed where producers wanted them, not where the study design required them to be. As a result BMPs were often placed in the 'control' watershed. Also producers did not participate in all of the practices. For example, the work plan for the implementation called for the installation of 52,500 acres of grassed waterways (Thelen, 2004). Grassed waterways in cropland are unpopular with landowners due to incompatibility with large equipment. The rangeland, cropland and riparian areas in the control areas, Whitewater North and Powell Creek were to have been treated with BMPs including fencing, rotational grazing, alternative feeding and watering stations, and vegetation plantings. Ash and Whitewater South watersheds were to have been managed without BMPs, and serve as the controls.

In 2000, BMPs were implemented in the Whitewater North Creek watershed during the Whitewater Creek North Implementation Project. This $64,570 project implemented sediment traps, fencing 6200 ft. of riparian grazing exclusion areas, six drop or check structures, timber and rock barbs, and managed grazing.

BMPs were implemented in the Powell and Ash Creek areas as part of the Bad River Water Quality Project Phase 3. Construction started in 1995 including no-till row cropping, CRP, and riparian buffers (Vande Kamp, 2012). More BMPs including sediment control structures were implemented between 1997 and 2002 (Vande Kamp, 2012) in both Ash and Powell Creek watersheds. In 2002 grazing was changed from cattle to a managed grazing stocking rate of bison. Changing in grazing practices have major effects on the landscape are considered BMPs for the purpose of this monitoring project. Effectively BMPs were being implemented in Ash and Powell Creeks throughout the entire project.

MONITORING AND EVALUATION

The Bad River National Monitoring Project's goal was to compare vegetation and water quality responses in paired watersheds during a before-BMP calibration (1996-1999) period and after-BMP period (2000-2002) to measure the effect of the treatment. Initially the calibration period of BMP monitoring was scheduled to be 1996-1997. However BMPs were not installed in the Whitewater watershed until 2000 giving us an additional year of calibration data in 1999. The second pair of watersheds, Ash Creek and Powell Creek, became in effect two treatments as BMPs were installed in both watersheds, effectively losing the control. BMPs installed in the Ash and Powell watersheds started in 1995 and continued till 2002, therefore there are no 'before-BMP' or 'after-BMP' periods. In no way can conclusions about effectiveness of BMPs be drawn from the Ash or Powell watershed data though vegetation and TSS response in those watersheds can be shown for each year of the study independent of any treatment effect.

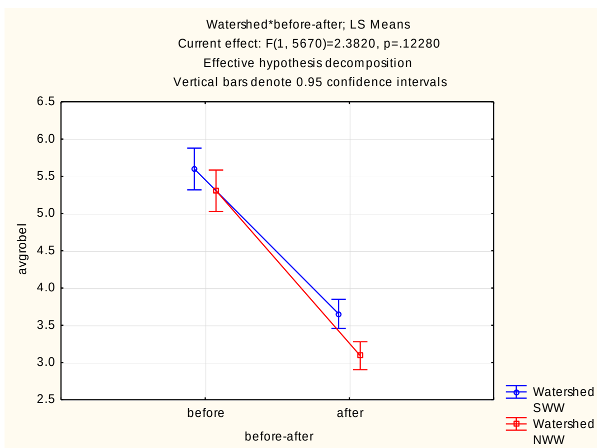
Vegetation monitoring included Robel pole height measurement and cover class assignment of the categories rock, litter, bare ground, grass, forbs and shrubs using the Daubenmire frame. Since Robel pole heights are commonly pooled, the average Robel height for each station in the transect was used as a dependent variable of interest. There are height readings taken per station, twenty-five stations per transect and 10 transects per site in NWW (T), 9 transects in SWW (C), Ash Creek — 21 transects (C), Powell Creek — 13 transects(T). Bare ground cover class was a variable of interest since bare ground is a ready source of erosion and a good indicator of range condition. The final variable of interest was total vegetation cover, summed from grass, forb, shrub cover which could equal more than 100%. Cover class variable were back-transformed to their mid-point cover percentages, the cover value. Cover values were non-normally distributed and analyzed using the Wilcoxon Signed Rank test.

Cover class	Percentage range	Cover value
0	0	0
1	1-5 %	0.025
2	6-25%	0.15
3	26-50%	0.375
4	51-75%	0.625
5	76-95%	0.85
6	96-100%	0.975

As discussed previously there was no detectable ‘before-BMP’ or ‘after-BMP’ period for Ash and Powell as BMP installation was ongoing from 1995-2002. Results are presented by year but no conclusions are drawn from them. For the Whitewater North (T)-South (Control) pair, there were only 4 pre-treatment measurements, the spring of 1996, the summer of 1997, and spring and summer of 1999. If vegetation dynamics after the drought had stayed similar to those beforehand, the calibration period would have been sufficient. Unfortunately the Bad River region entered a drought in 2000, the same time BMPs were installed, masking any improvements to range quality. Since range condition is highly dependent on season and has great annual variability, it is commonly measured throughout the year to get an idea of how the range condition changes throughout the year. Measurements taken over a number of years should be taken either at green-up, peak season or end of season then either compared within the year to measure variability or compared only to those same time periods in other years. ‘Season’ and ‘year’ were also included in the model to capture spatial variability and ensure independence of samples. An unequal number of seasons by year and skipping certain years made the data unbalanced as well. A BACI design (Before-After-Control-Impact) was used with the dependent variable divided into ‘before- BMP’ and ‘after-BMP’. Site location represented ‘control’ at Whitewater South or ‘impact’ at ‘Whitewater North’. The interaction between ‘before-after’ and ‘control-impact’ tested the treatment effect (Smith, 2002). In addition ‘season’ was needed to capture intra-annual variability and ‘year’ was needed to capture inter-annual variability since range condition is highly year and season dependent. Time periods measured were spring 1996, summer 1997, spring 1999, summer 1999, spring 2000, summer 2000, fall 2000, spring 2001, summer 2001, fall 2001, spring 2002 and summer 2002.

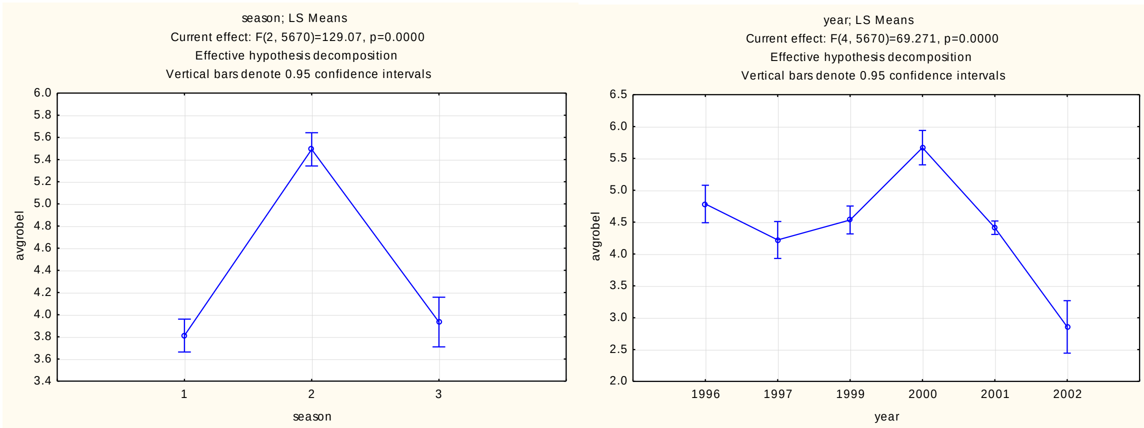
Average Robel pole height, percent vegetation cover and percent bare cover were the dependent variables. Watershed (NNW or SSW), time (before or after), year (1996, 1997, 1999, 2000, 2001 or 2002) and season (spring, summer, fall) were categorical predictors. The variable of interest was the watershed*time (before-BMP or after-BMP) interaction which is the treatment effect. This interaction term shows how the different sites, the control and impact respond differently and is illustrated by the slopes of the two terms’ lines. The graph below does not account for year or season which is a significant source of variation, however it illustrates the average Robel height by time. The interaction is not significant (F=2.38, p=.1227) and so no significant treatment effect is found (Figure 4).

Figure 4: Watershed* ‘before-after’ interaction in the Whitewater Creek watershed



Each pair of watersheds responded similarly to the variety of climatic conditions throughout the project so at this scale there is no evident treatment effect. The graphs below show the importance of intra-annual and inter-annual variability on vegetation height.

Figure 5: Intra and inter-annual variability



A planned contrast (1 -1 -1 1) was used to test the watershed* time interaction (F= 2.38, p=.1220). Watershed, season and year were all significant predictor variables. After performing statistics on the more robust pair of watersheds, there was sufficient evidence to reject the premise that the treatment had an effect on vegetation. There is a trend of decreasing average Robel height over time.

Figure 6: Whitewater North (T) -South (C) average Robel height by year and difference between control and treatment means

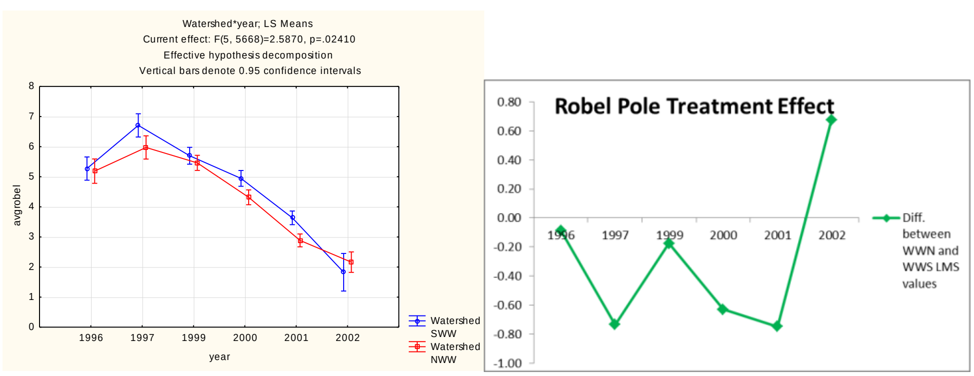
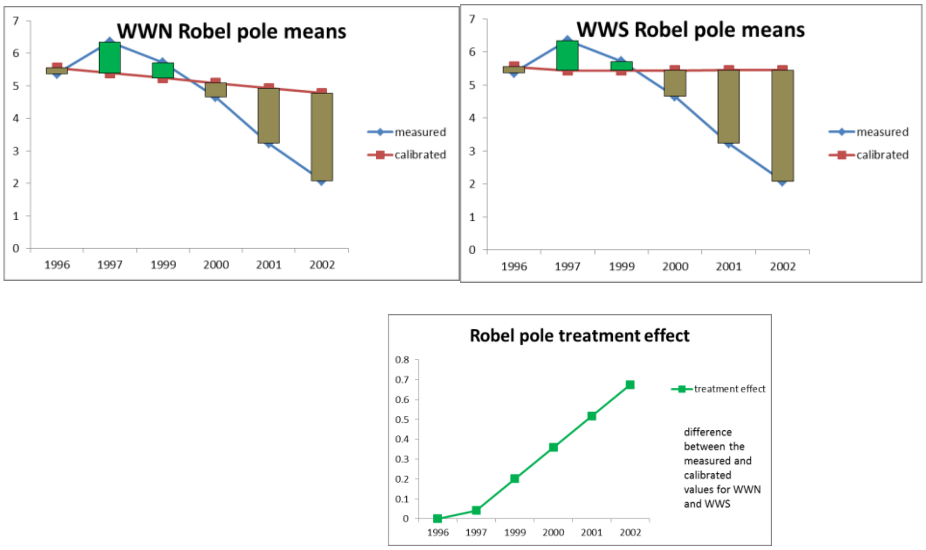


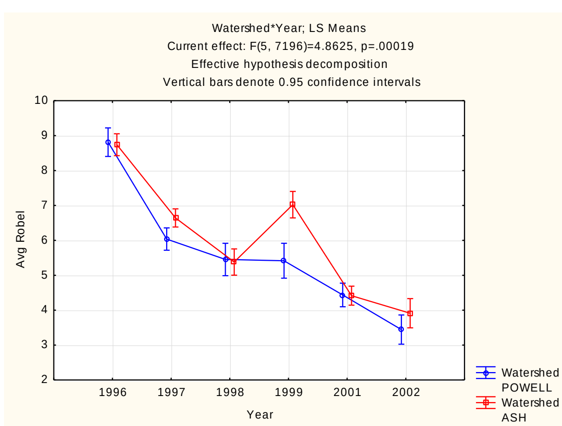
Figure 7 shows the treatment effect of measured and calibrated Robel heights for the treatment minus the control watershed based on each watershed's calibration periods. Calibration values for each watershed by year were calculated based on a regression line of the least mean squares for 1996-1999. No significant treatment effects when classifying by 'before' vs. 'after' were found in the ANOVA previously. The by-year trend does show the effect by year between Whitewater North (treatment) and Whitewater South's difference in values. Whitewater North actually shows a treatment effect as it has a smaller difference between measured and calibrated values than the control, Whitewater South.

Figure 7: Regression analysis on average Robel heights and difference between treatment and control means.



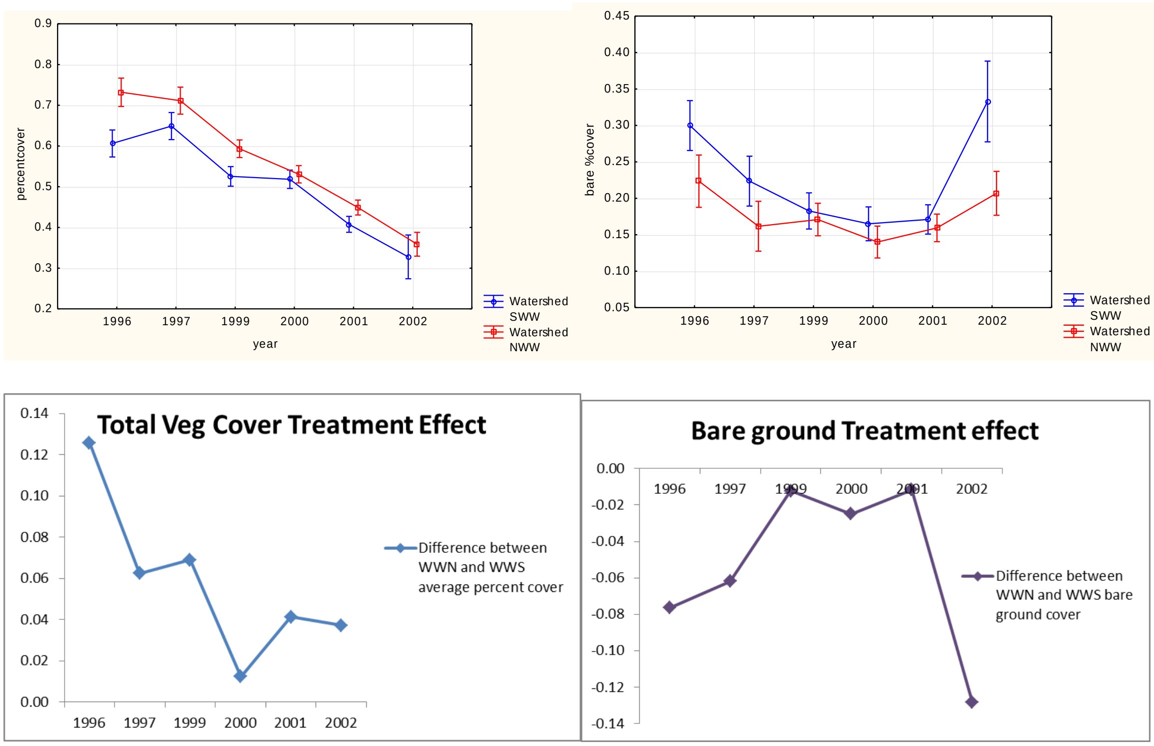
Powell Creek and Ash Creek were supposed to be another treatment-control pair. Riparian and range management improvements were planned for the Powell Creek watershed. However after changes in land ownership, both watersheds received substantial treatments. Both watersheds are considered treatments for the duration of the study. 21 transects were monitored in the Ash Creek watershed, 13 transects were monitored in the Powell Creek watershed. There was no clear-cut before-BMP or after-BMP time period variable that could be analyzed. The same predictor variables, watershed, year and season, were used. Without a control in that watershed or a time effect, the effects of the any BMP treatment cannot be analyzed.

Figure 8: Ash (C) - Powell (T) average Robel height by year



Total vegetation cover and bare ground cover were examined nonparametrically. While both variables pass the Friedman ANOVA test, [percent vegetated cover: (N=1074, df=3), Chi sq =300.45, $p<.00001$] it isn't surprising that more than one treatment group is different. When further analyzed with the Wilcoxon signed rank test, before-WWN (Whitewater North) and before-WWS are different, (Z=6.78, $p<.0001$) . After- WWN and after-WWS are different (Z=3.89 p=<.0001). Total vegetation cover is shown below. Since one would expect vegetation cover to increase if there were a treatment effect, graphically one can see there is no treatment effect. Lastly bare ground cover was examined. Areas of exposed bare ground are serious contributors to erosion and indicators of poor range health. Again as a cover variable, data was examined nonparametrically. According to the Friedman ANOVA bare cover: (N=1501, df=3), Chi sq =59.44, $p<.00001$)], at least one mean is significantly different, however a treatment effect cannot be ascribed to it. When further analyzed, before-BMP WWN and before-BMP WWS are different, (Z=3.85, $p<.0001$) and after-BMP WWN and after-BMP WWS are different (Z= 2.76, p=.0057). The below graphs are for illustration purposes only, as this is highly nonnormal data. However the fact that the bare ground cover is highly year dependent and that both sites respond in the same manner is evident. Perhaps the increase in bare ground cover is drought-related.

Figure 9: Whitewater North(T) and South (C) total vegetation cover values and bare ground cover values.

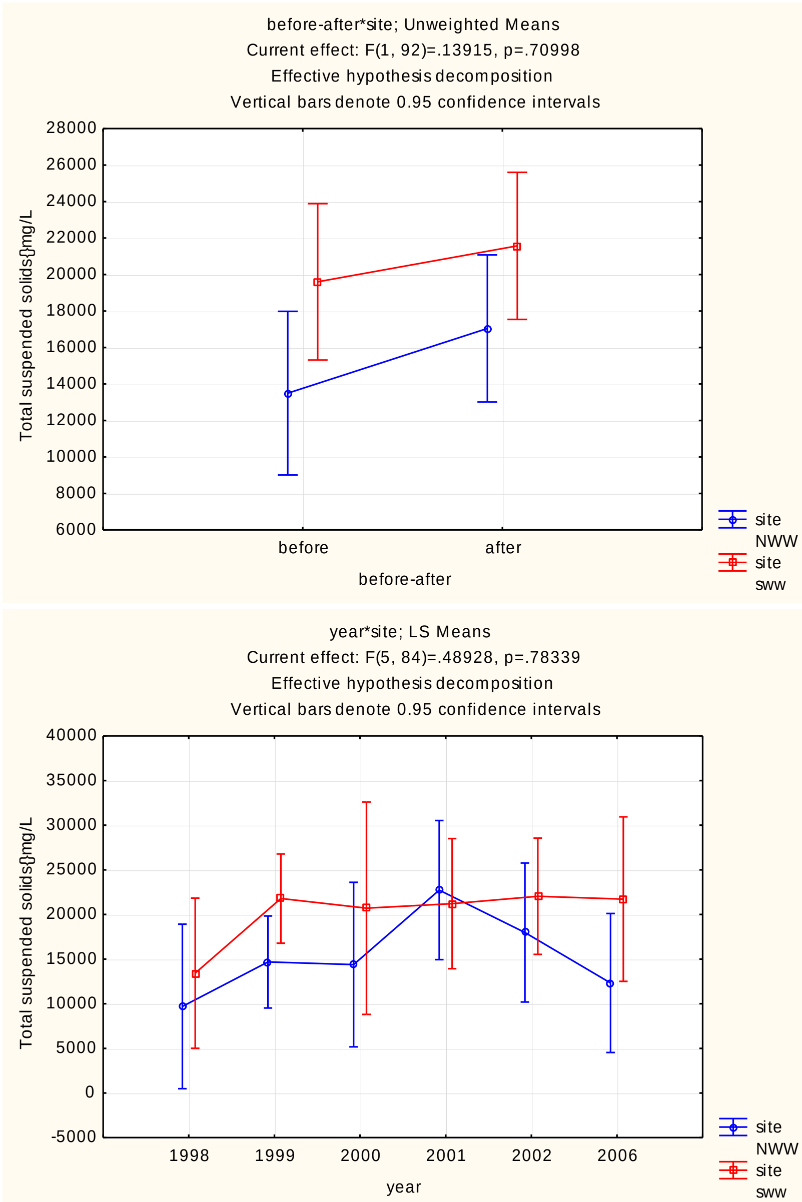


In 2002 there may be a divergence in how the treatments respond, it is difficult to tell. It is promising that the treatment watershed had significantly less bare ground cover in 2002 than the control. More years of sampling may have been helpful. Bare ground varies throughout the project length and so any BMP-linked reduced-TSS downstream outcome would be tenuous. The BACI experimental design works best when an immediate and permanent treatment effect is expected as well as an expected difference in means. This design can underperform in long-term monitoring or where changes in variability in means occur (US EPA, 1997).

The Bad River Monitoring Project required an evaluation of BMPs installed during this project to reduce sediment loads downstream. Evaluation of BMP treatments require sufficient calibration period, a treatment and control pair, and a clear understanding of what those treatments are and what they hope to do. A BACI design is preferred as it can account for environmental variability, and pairing with a control which is essential for evaluating a treatment (US EPA, 2003). The treatment effect is directly measured by the interaction between the before-after variable (time) and the control-impact variable (site). A before-after approach can be misleading with so much annual variability in range condition. Other factors can have a profound effect on vegetation including grazing, temperature, and above all rainfall, of which site-specific data is not available. Grazing rates and access were changed during the treatment period but it is unknown by how much. It is unknown how BMPs were installed relative to transects to even hypothesize how study areas would be affected the magnitude of those BMPs When a study is designed, there should be specific questions asked, specific protocols and a specific method in mind to analyze the data. There were numerous people involved in this project. Some data was not collected for practical reasons but lack of central management hurt the ability to monitor. One half of the study was unable to be fully analyzed as the control watershed was lost. It also takes time to see a treatment effect. Measureable responses after BMPs can take 5 to 20 years to become apparent (US EPA, 2007). A severe drought cycle was entered in 2000. Vegetation responses are muted during a drought. Production is reduced due to decreased soil moisture. Green-up can be delayed and senescence can come early. Some forb species remain dormant during a drought. More erosion can occur during or after a drought without plant roots to support the soil. The timing of BMP installation relative to the drought made it difficult to evaluate the effectiveness of those BMPs.

Total suspended solids (TSS) data was collected intermittently throughout the project to assess any decrease in TSS due to treatments. BMPs were installed in 2000. Again the BACI design was used with the dependent variable classified into 'before-BMP' and 'after- BMP'. Site location determined control or impact and the interaction between time period and site tested the treatment effect. There was a huge range of variability in the TSS samples in the calibration period ranging from 4650 to 26000 mg/L. TSS did differ significantly by site, ($F=6.283$, $p=.0140$). It is of interest to note that the 'before-after' variable is not significant, ($F= 1.69$, $p=.1970$) meaning the periods were not different from each other. The treatment effect is the relative slope of the lines for each watershed's 'before-after' response, if there is no treatment effect parallel lines are expected, if there was a treatment effect, those lines would cross. The treatment was not significant, ($F= .139$ $p=.7099$) as shown in Figure 10.

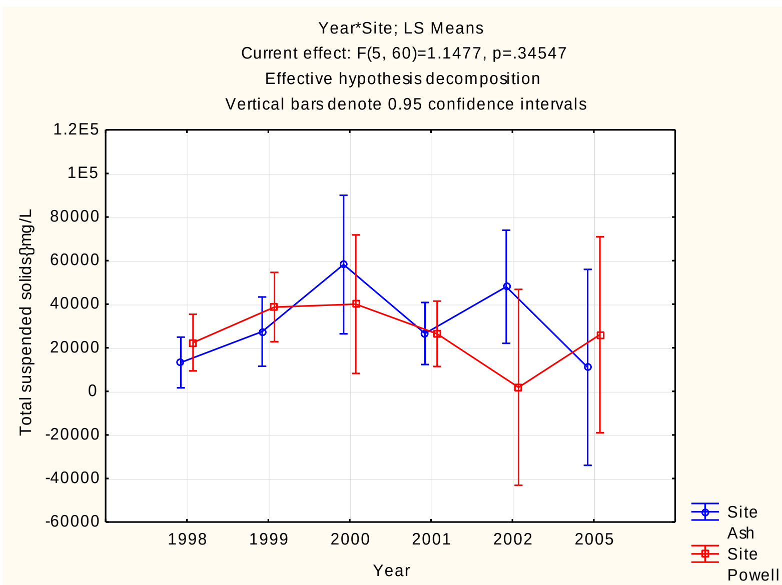
Figure 10: Whitewater North (T) and South (C) TSS



2001 had a strong effect on pulling the WWN site's TSS upward. The last three years of measurements do show that Whitewater North's TSS is beginning a downward trend.

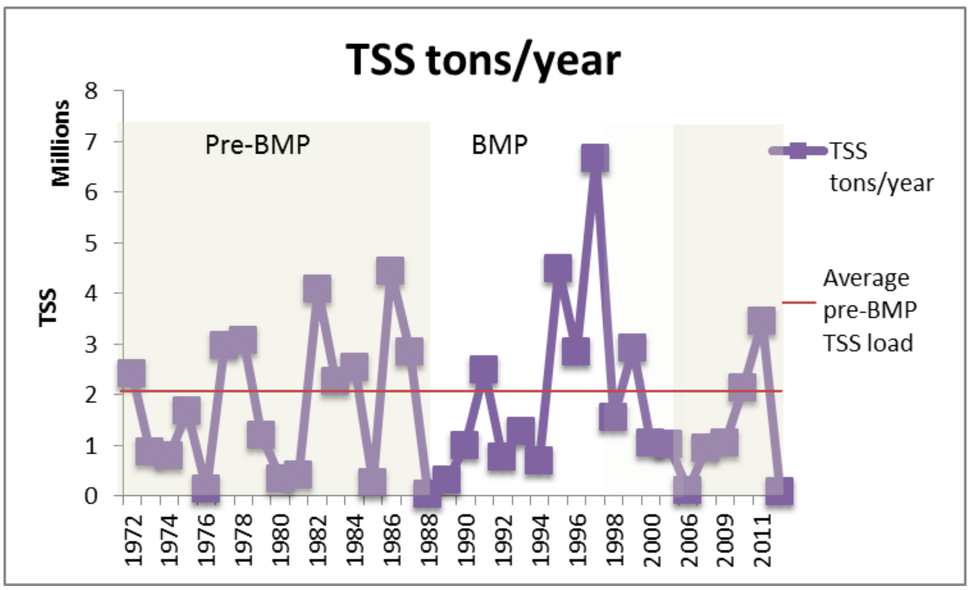
The Ash-Powell watershed was examined to determine if there was any trend in TSS data. This pair could not be analyzed like Whitewater North and Whitewater South as there was no treatment or even ‘before-BMP’/ ‘after-BMP’ period. TSS increases as time elapses so the treatment if it exists did not reduce TSS. Flow is a necessary covariate for analyzing TSS however it is spotty and unreliable. When TSS is analyzed at the Powell site, it is an insignificant predictor, (F=.300, p=.5880). Individual site scatterplots are shown in the Appendix.

Figure 11: Powell (T) and Ash (C) TSS



Despite these design setbacks there is evidence that BMP installation was successful in related studies. Using remote sensing, SDSU scientists were able to quantify warm season grass channel cover which has been linked to healthier less erosive streams when comparing before- and after- BMP time periods. They showed a positive correlation between BMPs and this favorable grass. Large reductions in sediment were claimed in the 2004 Bad River Phase III report. These reductions were based on the USDA’s 1998 report claims the Bad River discharges 3.25 million tons of sediment a year to Lake Sharpe. This is reported by the ACOE 1948-1986. Only 5 years of data post-1972 were at or above the supposed average of 3.25 million tons of sediment. The Bad River Phase III Report cites a 31% reduction in sediment at Fort Pierre from 1972-1994 compared to 1995-2000. This ACOE average data does not properly represent improvements in the Bad River watershed due to BMPs. Since the 3.25 million figure does not properly represent average sediment loads and as BMP installation and land use change were ongoing from 1991-2002, the data was reanalyzed and the last few years of data added. Sediment deposited at the mouth of Bad River into Lake Sharpe decreased from pre-BMP (1972-1991) to post-BMP periods (2003-2012) (F=5.50, p=.0088) taking into account flow as a covariate (Figure 12)(USGS, 2012). On average TSS decreased from 1945 +/- 175mg/L in the pre-BMP period to 757 +/- 312 mg/L in the post-BMP period, a 61 % decrease. The overall load (tons/day) decreased by 50% from 2.13 million tons per year to 1.06 million tons per year when accounting for changes in flow from the pre-BMP to post-BMP period. Caution is urged when looking at averages. TSS is highly variable and changes yearly. For example the sediment load was over 3,458,010 tons/year in 2011 but only 90,593 tons in 2012.

Figure 12: Annual Bad River TSS tons discharge to Lake Sharpe



When flow, which is a very important covariate is not accounted for, there is no BMP effect (F=1.07, p=.3520).

COORDINATION EFFORTS

The following organizations contributed to the success of this project:

East Pennington Conservation District – Local Sponsor. District staff included the project coordinator and business manager who were supervised by District Board of Supervisors. The district coordinated project activities, reported on project activities and progress, vouchered for grant funds, and provided record keeping.

Stanley County Conservation District – Local Sponsor. District staff included the project coordinator and business manager who were supervised by District Board of Supervisors. The district coordinated project activities, reported on project activities and progress, vouchered for grant funds, and provided record keeping.

U.S. Forest Service – The United States Forest Service, Buffalo Gap National Grasslands contributed $20,000 for construction of BMPs.

Natural Resources Conservation Service – (Wall Field Office and Rapid City Field Support Office) NRCS provided technical assistance. Field office staff management involved with the project included a soil conservation technician, range conservationists, soil conservationists, soil scientist, and agricultural engineer staff.

SD DENR – Administered the EPA 319 grant funds, served as a consultant for technical information and project planning related to water quality.

Upper Bad River Task Force - Group comprised of ranchers and agency personnel that were committed to improving water quality in the Bad River watershed and met to discuss nonpoint source pollution control strategies.

South Dakota State University- Two master's theses were produced in conjunction with this project. SDSU scientists examined the effectiveness of BMPs using remote sensing. At least 4 papers have been published to date as part of this study.

US EPA- Provided funding for National Monitoring Project and Bad River Phase III Implementation under 319 NPS funding.

Private landowners were participants in the project.

PROJECT BUDGET/EXPENDITURES

Section 319 watershed funds were used in the Bad River watershed to implement BMPs under the Whitewater Creek North and Bad River Phase III projects. This watershed was also given priority status for funding under the U.S. Department of Agriculture EQUIP (Environmental Quality Incentive Program). Matching funds were provided by the State of South Dakota and participating private ranchers.

FUNDING:	TOTAL BUDGET	383,706
	TOTAL EPA GRANT(S)	303,406
	OTHER FUNDING	80,300
	TOTAL EXPENDITURES OF EPA FUNDS	
	TOTAL SECTION 319 MATCH ACCRUED	
	TOTAL EXPENDITURES	

Project Element	Funding Source ($)			
Federal	**Federal**	**State**	**Local**	**Sum**
Land Treatment	154,428	2,000	NA	156,428
WQ Monitoring	148,978	18,300	NA	167,278
Add'l Robel Pole			60,000	60,000
TOTALS	303,406	20,300	60,000	383,706

Source: Bad River National Monitoring Project Workplan, 1996

PUBLIC PARTICIPATION

BMPs were installed on land owned or leased by participating ranchers in the project area. In a related study by SDSU scientists investigating the effectiveness of BMPs in the Bad River area, the CEAP project (Conservation Effects Assessment Project), found that producers' project satisfaction was high even after the study was complete. 92% of participating producers saw sediment produced in the basin as a problem. 91% had implemented BMPs to reduce sediment and improve water quality. 85% of producers would implement conservation practices if there was no gain or loss to their farm and 100% would implement practices if there was a financial advantage. Proven sustainability of conservation practices was cited by producers as the most influential factor in deciding to implement practices. See attachment: (Stover, 2012).

The Upper Bad River Task Force was a group comprised of ranchers and agency personnel that were committed to improving water quality in the Bad River watershed and met to discuss nonpoint source pollution control strategies.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

The Bad River Monitoring Project required an evaluation of BMPs installed during this project to reduce sediment loads downstream. Though there were some successes and evidence that BMP installation was successful in reducing sediment, the approach taken by the NMP did not work well at all. There were major problems with project design. Some factors were beyond the project's control: how and when BMPs were installed and the major landowner change which unpaired one of the paired watersheds. Some of the equipment was incompatible or did not work well with the low flow and sediment-laden creeks. A major drought began just as BMP installation was ending. The most serious problem was probably lack of consistent leadership in the project. Records were lost and it was difficult to tell exactly what had been done.

Evaluation of BMP treatments require sufficient calibration period, a treatment and control pair, and a clear understanding of what those treatments are and what they hope to do. A BACI design is preferred as it can account for environmental variability, and a paired with a control which is essential for evaluating a treatment (US EPA 2007). The treatment effect is directly measured by the interaction between the before-after variable (time) and the control-impact variable (site). A before-after approach can be misleading since there is so much annual variability in range condition, the 'before' period is oftentimes quite different than the 'after'. A pre- or post- treatment category was unable to be assigned to Ash Creek sites because there was so much land use change and BMP installation going on from 1991- 2002 (Rigge, 2013). The Powell and Ash sites ceased to be a treatment-control pair due to uncontrollable outside factors. Other factors can have a profound effect on vegetation including grazing, temperature, and above all rainfall. Data is unavailable on those variables. Grazing rates and access were changed during the treatment period, how much so is unknown. The primary question when analyzing the data was 'is there a BMP-treatment effect'? This study could have been much more useful if there were questions asked in the planning process instead of gathering TSS and rangeland data and hoping something useful would emerge from the data. When a study is designed, there should be specific questions asked, specific protocols and a specific method in mind to analyze the data. The study design should also be appropriate to what is possible politically. BMP type and placement depended on producers' preferences and could not be even broadly controlled to exclude treatments from a watershed.

One half of the study was unable to be fully analyzed as the control watershed was lost. The 'before-BMP' period was planned to be 1996-1999 and 2000-2002 was planned as 'after-BMP'. With treatments and land use change ongoing from 1991-2002, that schedule could not be followed. Measureable responses after BMPs can take 5 to 20 years to become apparent (US EPA, 2007). Long-term monitoring may have revealed treatment effects. Calibration data collection is important before treatments begin. However it may take years for effects to become apparent. Measuring every 5 years thereafter for twenty or so years may have revealed treatment effects. Also the region entered a severe drought cycle in 2000. Even more erosion can occur during or after a drought without plant roots to support the soil. Vegetation responses are muted during a drought. Production is reduced due to decreased soil moisture. Green-up can be delayed and senescence can come early. Some forb species remain dormant during a drought. Riparian areas were not specifically surveyed which might have preferable if one of the monitoring objectives included "monitoring riparian condition to determine the effects of BMPs on the condition of riparian habitat." The pins to measure erosion were never used and photo point collection was erratic. The timing of BMP installation relative to the drought made it difficult to evaluate the effectiveness of those BMPs.

There were also water sampling problems. Water quality sampling is storm event based so during the reporting period very few samples were collected due to a lack of precipitation. TSS samples were not integrated over the water column. Also flow meters clogged often and produced data of questionable quality. Problems occurred collecting data with flow meters clogging frequently. Storm intensity and precipitation varied from site to site, activation switches corroded, and rodents ate through the insulation and the wire core of the activation switches. Water quality monitoring was flawed with meters and sampling units that did not work well in the sediment-laden Bad River. There were not enough TSS samples taken to gain any information from that source. Due to the drought and natural low flow conditions only 28% of events sampled at Whitewater Creek actually had nonzero flow (Rigge, 2013). 32% of events at Powell Creek had non-zero flow. Even restricting TSS data collection to storm events, only 45% of Powell collection events registered non-zero flow.

In the other pair of watersheds, Whitewater Creek north and south, it does little good to collect Robel pole data in the spring one year, then three times the next year , then in the fall the year after that. There was not sufficient before-BMP data. The before-BMP period was relatively wet then drought followed after the BMPs were installed. Ideally there would have been a better estimate of production variability to account for the major effect of the drought. Flow and TSS data were collected inconsistently. There may have been a mismatch between the type of monitoring equipment and the sediment-laden condition of the river.

There were numerous people involved in this project. The most serious flaw to this project was that project coordination was inconsistent. At SD DENR there were three different project officers involved at different points. There were many people from several different agencies that were involved in the planning, many who have since retired. Record keeping was spotty. Especially for long-term projects, consistent leadership is essential. Range monitoring in the Ash and Powell watersheds where there was no pre-BMP period probably either should not have continued or been modified so that some useful data could have been collected.

FUTURE ACTIVITY RECOMMENDATIONS

Monitoring is an essential part of environmental restoration. Without monitoring and achievement standards there is no way to judge the success of a project. In a world of limited resources those methods which have proven success are the ones to be utilized. Stover (2012) surveyed participating producers and found that the most influential factor in deciding to implement BMPs was proven success. Evaluation of expensive BMP treatments require sufficient calibration period, a treatment and control pair, and a clear understanding of what those treatments are and what they hope to accomplish. A good monitoring plan includes a sound design and a priori variables of interest. Vegetation monitoring in this case was done inconsistently and did not encompass the cycle of natural variability. A consistent project officer who knows the specifics of the project, keeps adequate records and would be able to adaptively manage, would greatly improve the project. A project diary can be a great asset.

Using the Robel pole is a quick and cheap method used to measure available forage for land managers and to measure available cover for wildlife. It is not generally used alone to gauge rangeland health. Daubenmire cover classes do provide a good estimate of cover. Rangeland health is the ability of a rangeland to conserve its soil and water resources (Herrick and Whitford, 1995). Increased size and frequency of bare ground patches corresponds to decreased vegetation cover which limits the ability to conserve soil and water (de Soyza et al., 2000). Soil stability, hydrologic indicators and some measure of an intact vegetation community are commonly regarded indicators of rangeland health and ecosystem function (Pyke, et al., 2002). Incorporating some of these metrics for a long-term project would be more applicable than Robel pole data. In a project whose objectives include "monitoring riparian condition to determine the effects of BMPs on the condition of riparian habitat" a riparian monitoring component should be included. There are many different methods available for quick assessment. Random photo points do not suffice as evidence of positive change.

This was a large sprawling project with lots of agencies and players involved. BMPs were placed in a way that made sense to NRCS and producers but not in a way that necessarily made sense for analysis. Future projects should try to fully capture BMP treatment differences. Monitoring projects should ideally be long-term to capture effects which may take years and infrequently measured or alternatively if a long-term study is not possible, use a smaller scale design but more tightly controlled and intensely monitored.

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APPENDIX

Figures A1-A4 Show individual TSS scatterplots by site.

Figure A1: Ash Creek TSS over time.

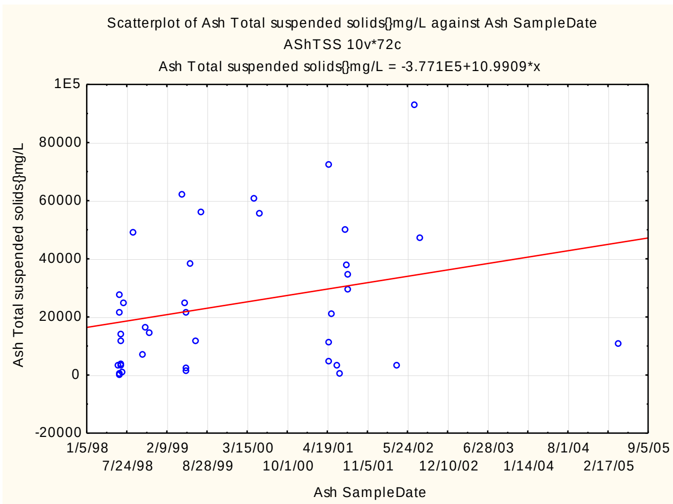


Figure A2: Powell Creek TSS over time.

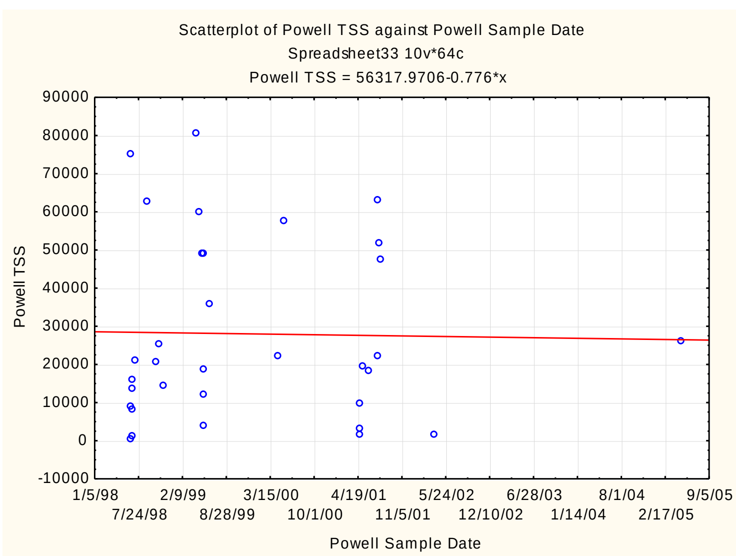


Figure A3: Whitewater Creek North TSS over time.

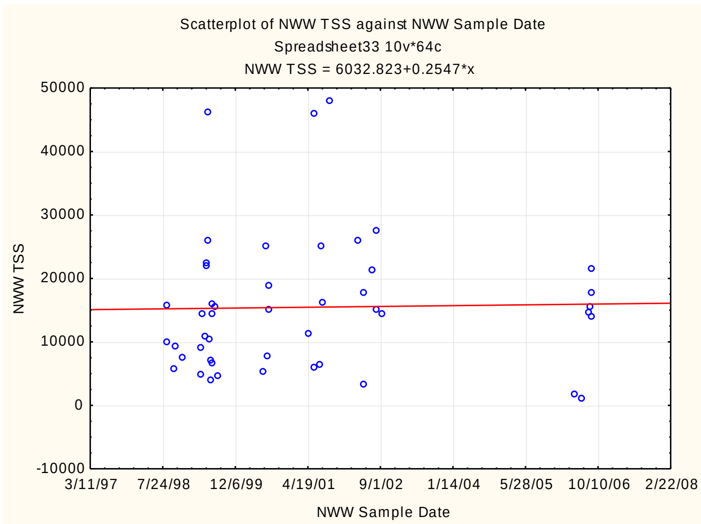
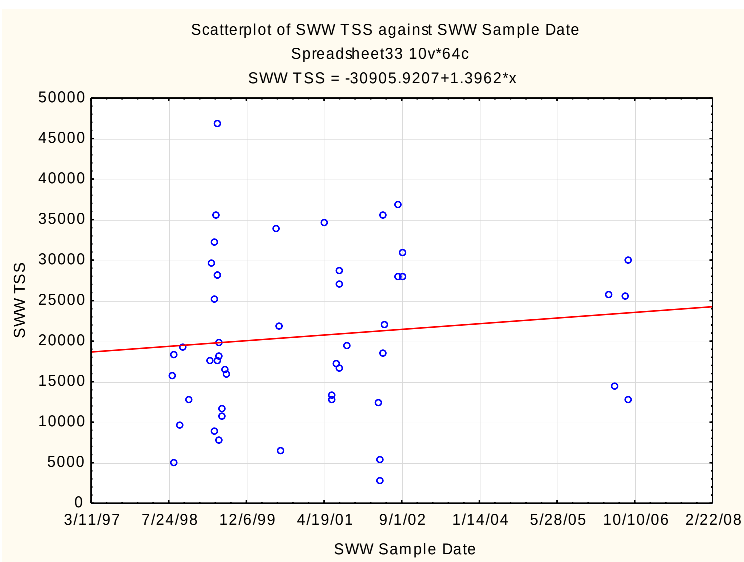


Figure A4: Whitewater Creek South TSS over time.



The following pictures are from Whitewater Creek North Implementation Project and the Bad River National Monitoring project and show equipment installation, problems and successes.

Flume installed at Whitewater Creek North during Whitewater Creek North Implementation Project (SD DENR). And below, after installation.

Uplands in Whitewater North

Ash Creek in June 2003 with vegetation growth in stream channel.

Solar powered equipment box

Bubbler tube prone to clogging

Robel pole and cover class data collection

Ash Creek Flume clogged with debris.